US009884357B2

(12) **United States Patent**
Taguchi

(10) **Patent No.: US 9,884,357 B2**
(45) **Date of Patent: Feb. 6, 2018**

(54) **METAL SEPARATOR MOLDING DEVICE AND METHOD FOR MOLDING METAL SEPARATOR**

(71) Applicant: **Nissan Motor Co., Ltd.**, Yokohama-shi, Kanagawa (JP)

(72) Inventor: **Naoto Taguchi**, Kanagawa (JP)

(73) Assignee: **Nissan Motor Co., Ltd.**, Yokohama (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 74 days.

(21) Appl. No.: **14/787,492**

(22) PCT Filed: **Apr. 3, 2014**

(86) PCT No.: **PCT/JP2014/059898**
§ 371 (c)(1),
(2) Date: **Oct. 28, 2015**

(87) PCT Pub. No.: **WO2014/188800**
PCT Pub. Date: **Nov. 27, 2014**

(65) **Prior Publication Data**

US 2016/0074919 A1 Mar. 17, 2016

(30) **Foreign Application Priority Data**

May 22, 2013 (JP) 2013-108064

(51) **Int. Cl.**

B21D 13/02	(2006.01)
B21D 22/02	(2006.01)
B21D 37/16	(2006.01)
H01M 8/0206	(2016.01)

(Continued)

(52) **U.S. Cl.**
CPC ***B21D 22/02*** (2013.01); ***B21D 13/02*** (2013.01); ***B21D 37/16*** (2013.01); ***H01M 8/0206*** (2013.01); ***H01M 8/0254*** (2013.01); ***H01M 8/0258*** (2013.01)

(58) **Field of Classification Search**
CPC B21D 13/02; B21D 22/02; B21D 22/022; B21D 37/16; B21D 24/005; B21D 24/16
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,450,707 A	5/1984	Ricard et al.
5,256,218 A	10/1993	Bakalyar et al.

FOREIGN PATENT DOCUMENTS

CN	1826361 A	8/2006
CN	1856892 A	11/2006
DE	10 2005 032 113 B3	2/2007

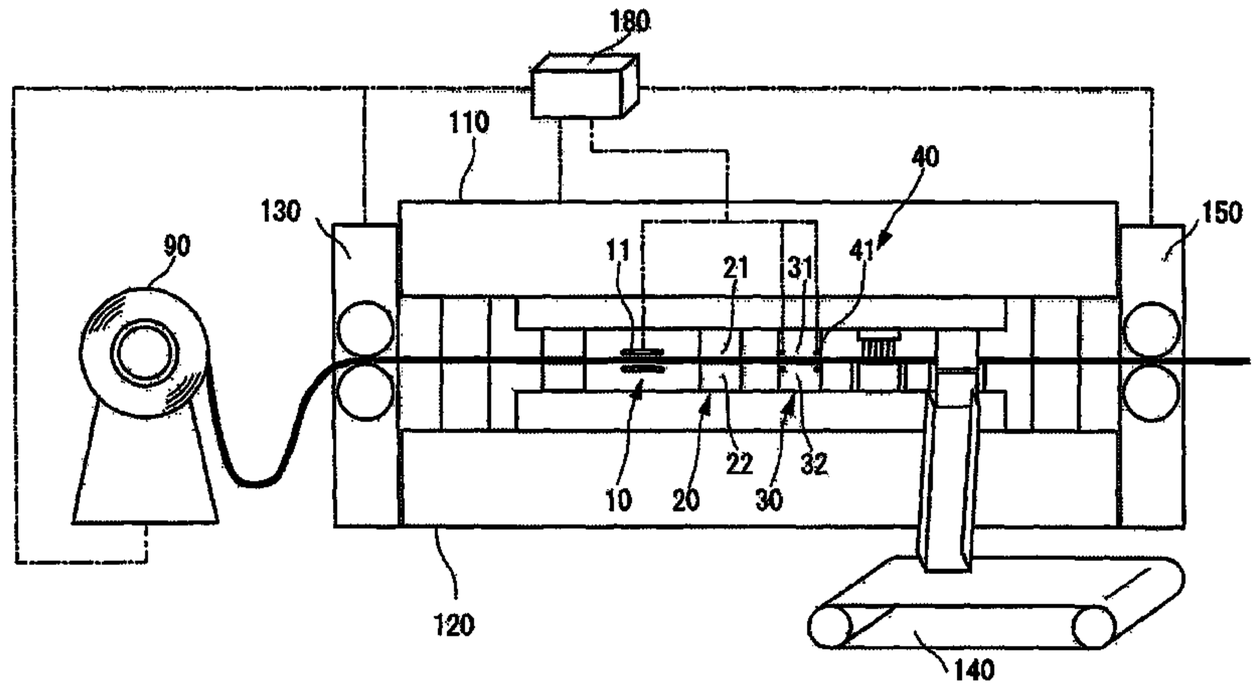
(Continued)

Primary Examiner — Debra Sullivan
(74) *Attorney, Agent, or Firm* — Global IP Counselors, LLP

(57) **ABSTRACT**

A metal separator molding device is provided for molding a metal separator by press-molding a thin plate-shaped base material by using a first die and a second die capable of moving towards and away from each other. The metal separator molding device has a first heating part for heating the thin plate-shaped base material, a channel-processing part for pressing the thin plate-shaped base material heated by the first heating part using the first die and the second die to form channels through which a medium flows, and a controller for controlling the operations of the first heating part and the channel-processing part.

13 Claims, 10 Drawing Sheets



(51) **Int. Cl.**
H01M 8/0258 (2016.01)
H01M 8/0254 (2016.01)

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

DE	10 2010 027 554	A1	1/2012
GB	2 077 634	A	12/1981
JP	2000-285934	A	10/2000
JP	2004-134090	A	4/2004
JP	2004-255648	A	9/2004
JP	2005-88075	A	4/2005
JP	2005-93391	A	4/2005
JP	2006-310020	A	11/2006
JP	2008-4291	A	1/2008
JP	2008-36699	A	2/2008
JP	2008068282	A *	3/2008
JP	2008-84843	A	4/2008
JP	2011-255413	A	12/2011

* cited by examiner

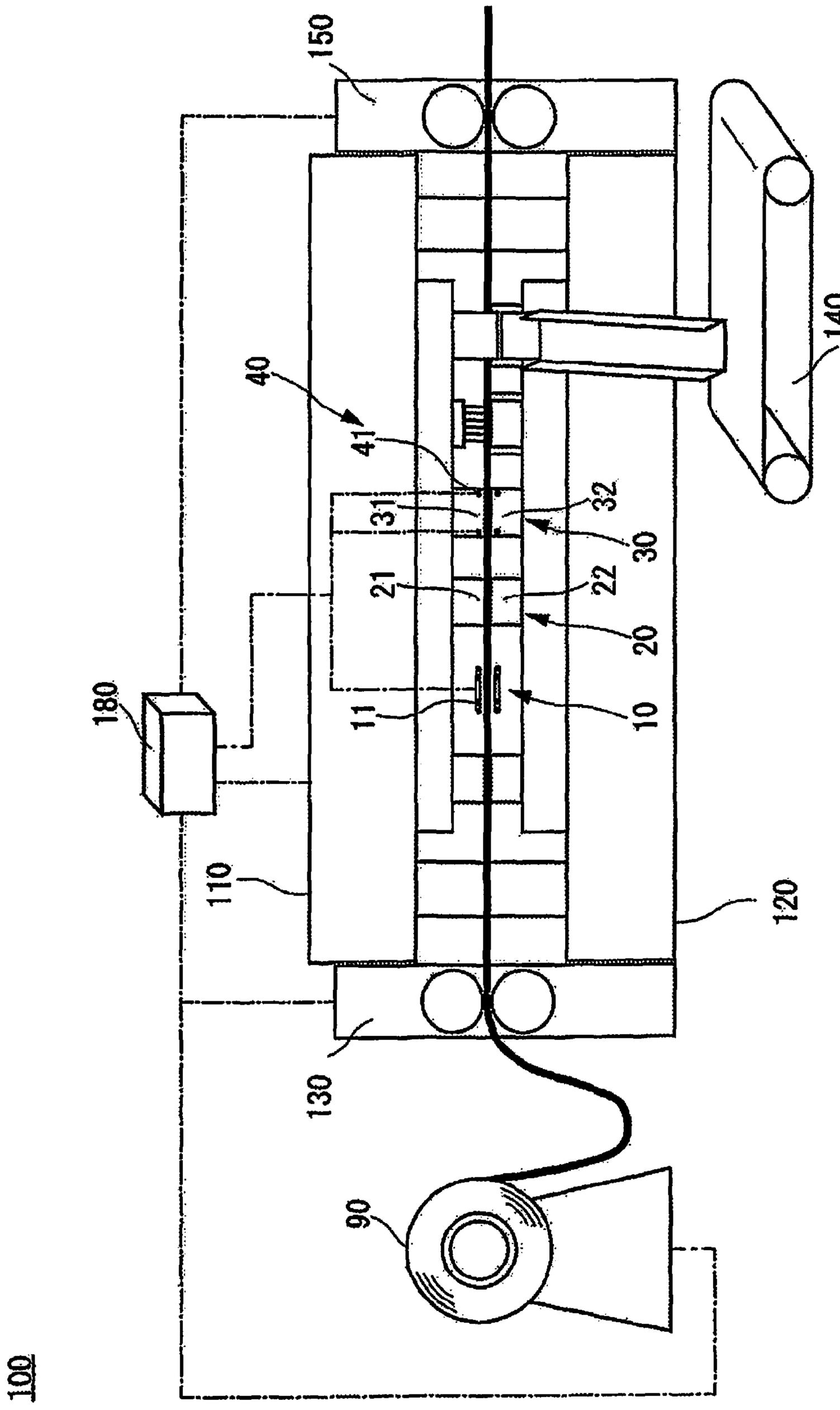


FIG. 1

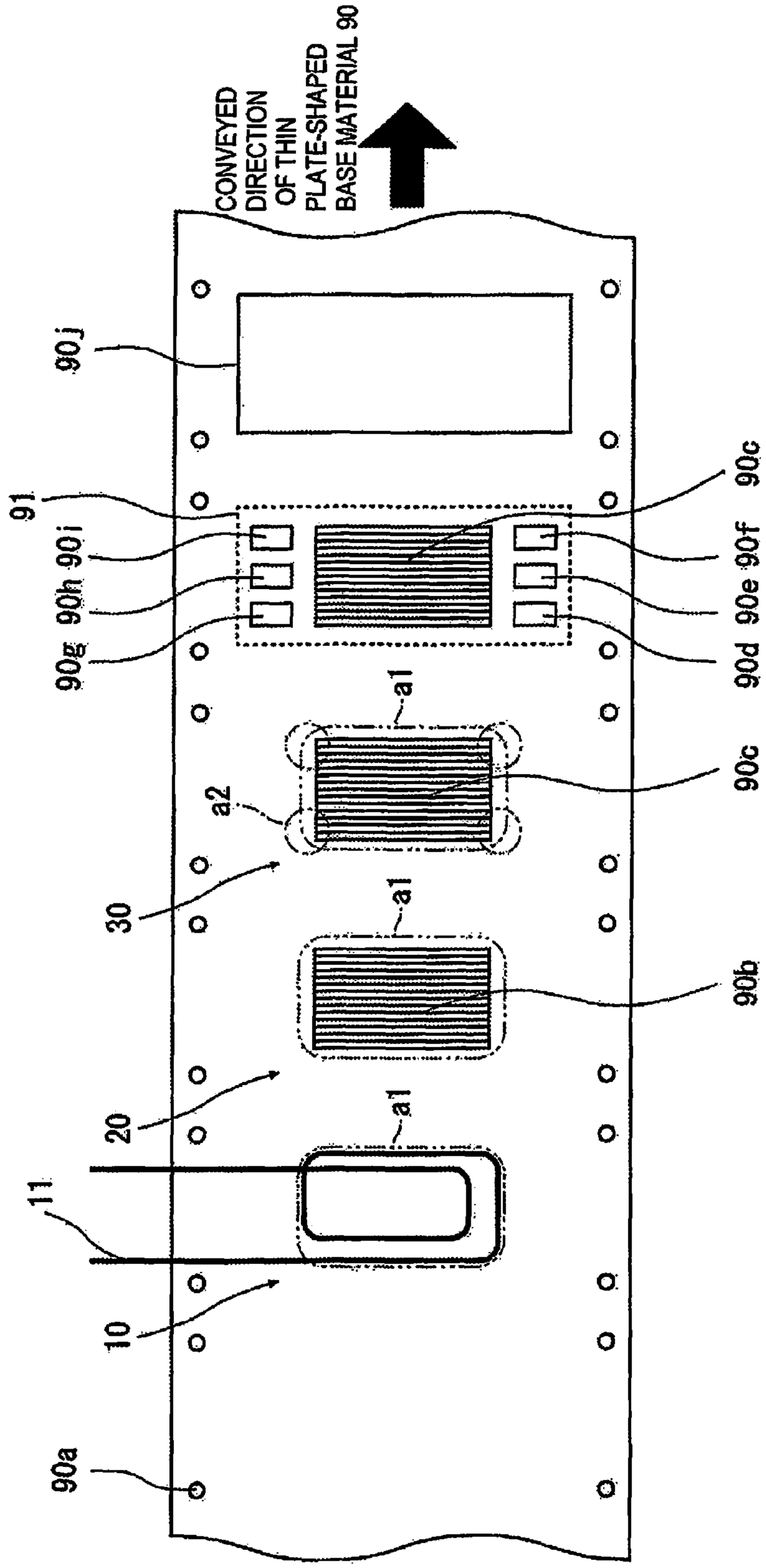

CONVEYED DIRECTION OF THIN PLATE-SHAPED BASE MATERIAL 90
90j
91
90i
90h
90g
90c
90f
90e
90d
a1
a2
90c
30
a1
90b
20
a1
11
10
90a
90

FIG. 2

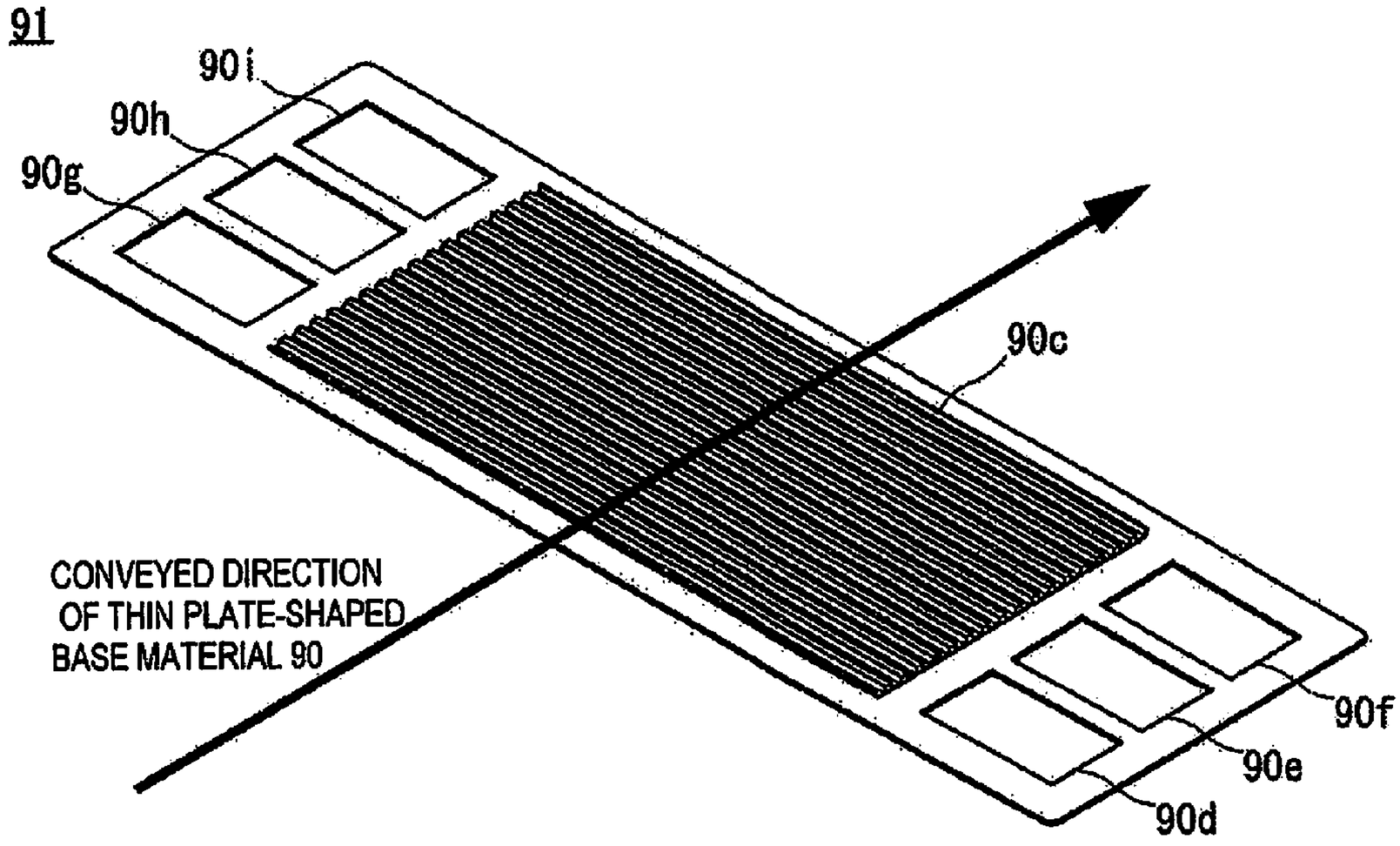

91
90i
90h
90g
90c
CONVEYED DIRECTION
OF THIN PLATE-SHAPED
BASE MATERIAL 90
90f
90e
90d

FIG. 3

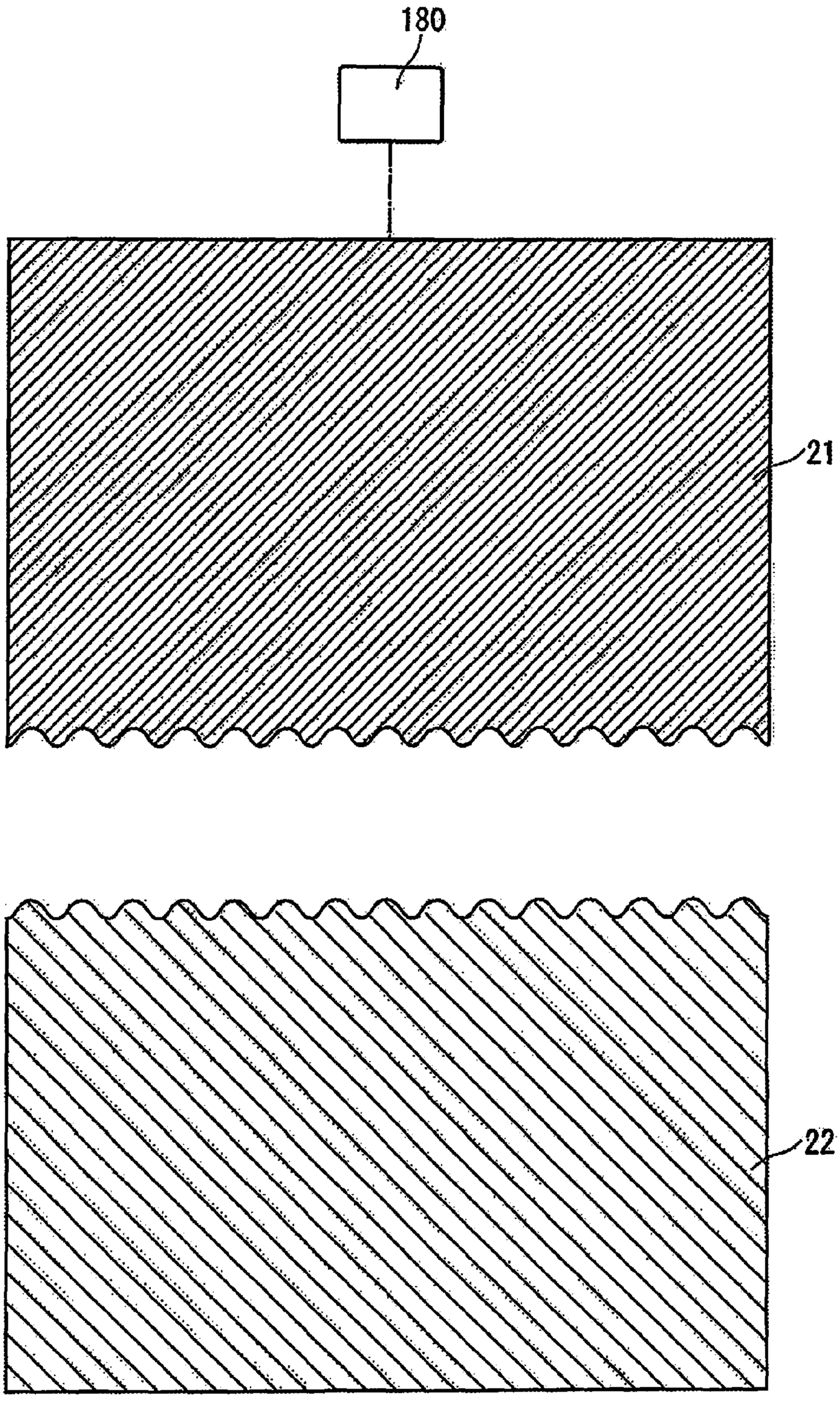


FIG. 4

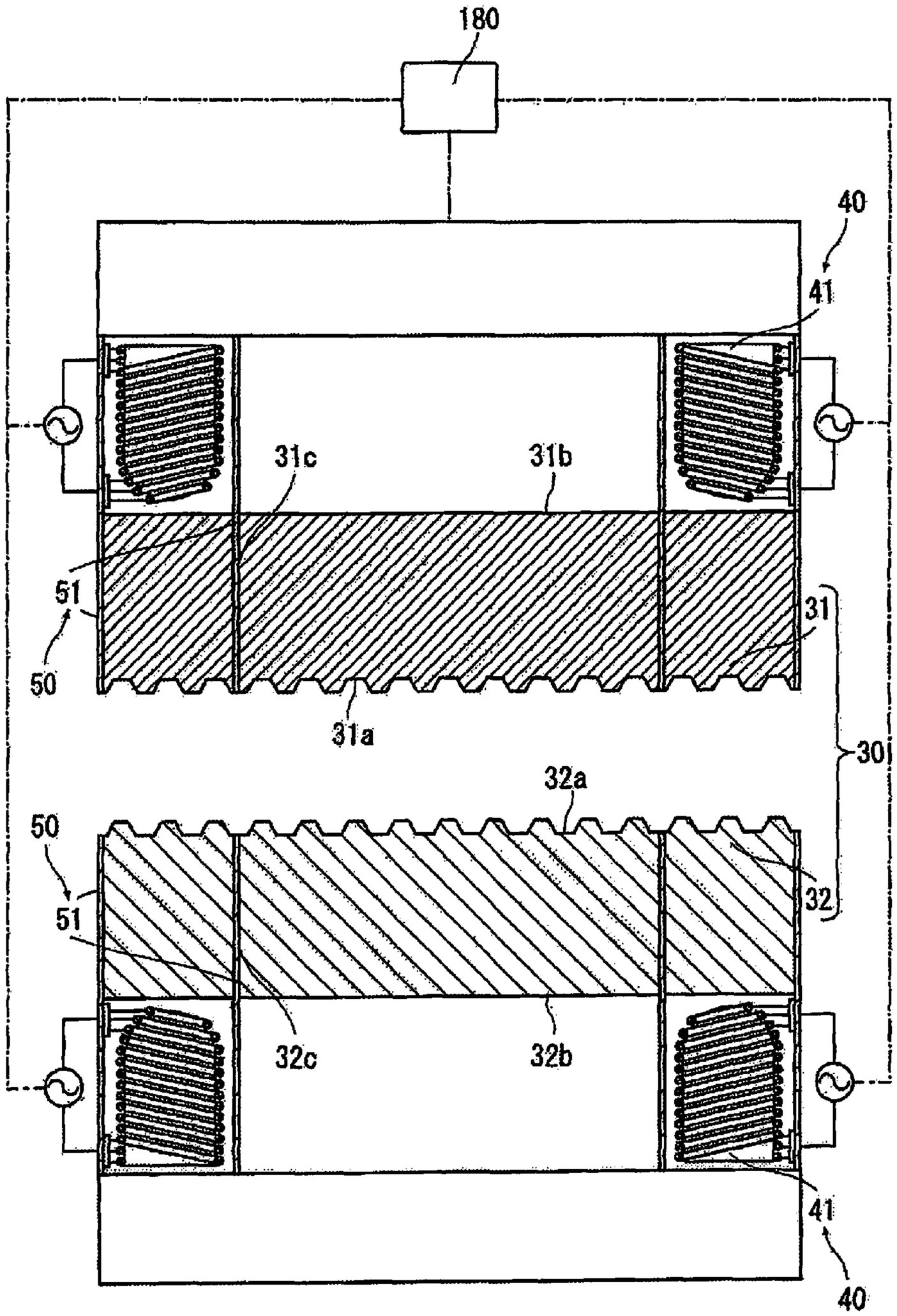


FIG. 5

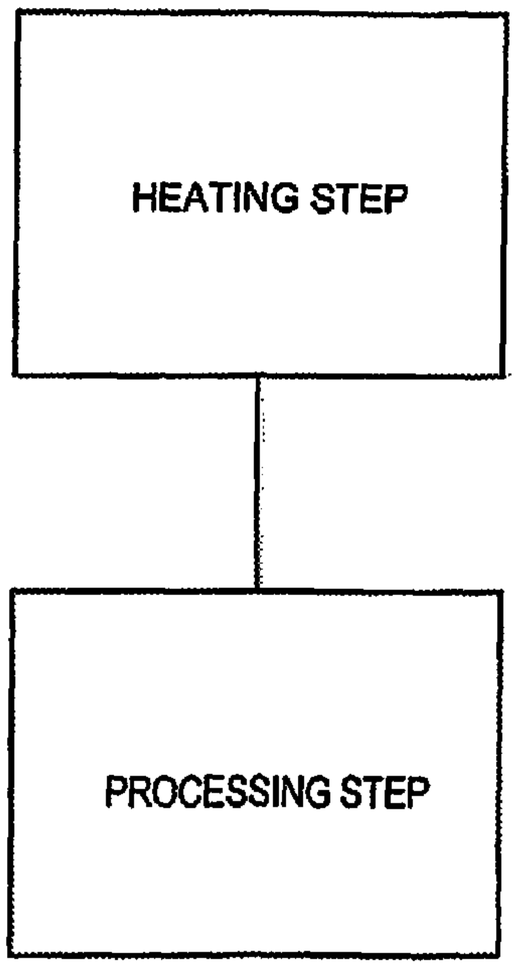

HEATING STEP
PROCESSING STEP

FIG. 6

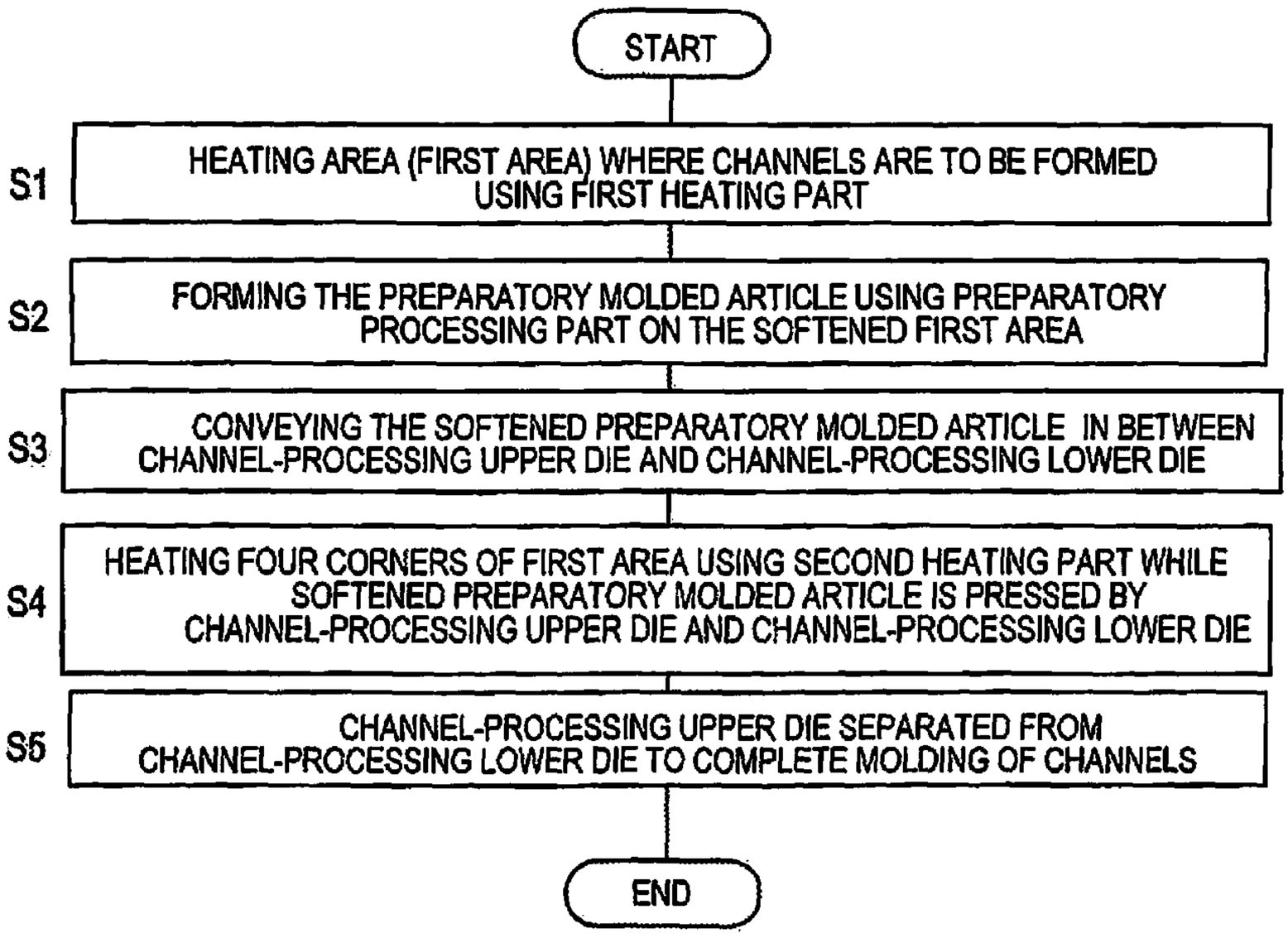

START
S1
HEATING AREA (FIRST AREA) WHERE CHANNELS ARE TO BE FORMED USING FIRST HEATING PART
S2
FORMING THE PREPARATORY MOLDED ARTICLE USING PREPARATORY PROCESSING PART ON THE SOFTENED FIRST AREA
S3
CONVEYING THE SOFTENED PREPARATORY MOLDED ARTICLE IN BETWEEN CHANNEL-PROCESSING UPPER DIE AND CHANNEL-PROCESSING LOWER DIE
S4
HEATING FOUR CORNERS OF FIRST AREA USING SECOND HEATING PART WHILE SOFTENED PREPARATORY MOLDED ARTICLE IS PRESSED BY CHANNEL-PROCESSING UPPER DIE AND CHANNEL-PROCESSING LOWER DIE
S5
CHANNEL-PROCESSING UPPER DIE SEPARATED FROM CHANNEL-PROCESSING LOWER DIE TO COMPLETE MOLDING OF CHANNELS
END

FIG. 7

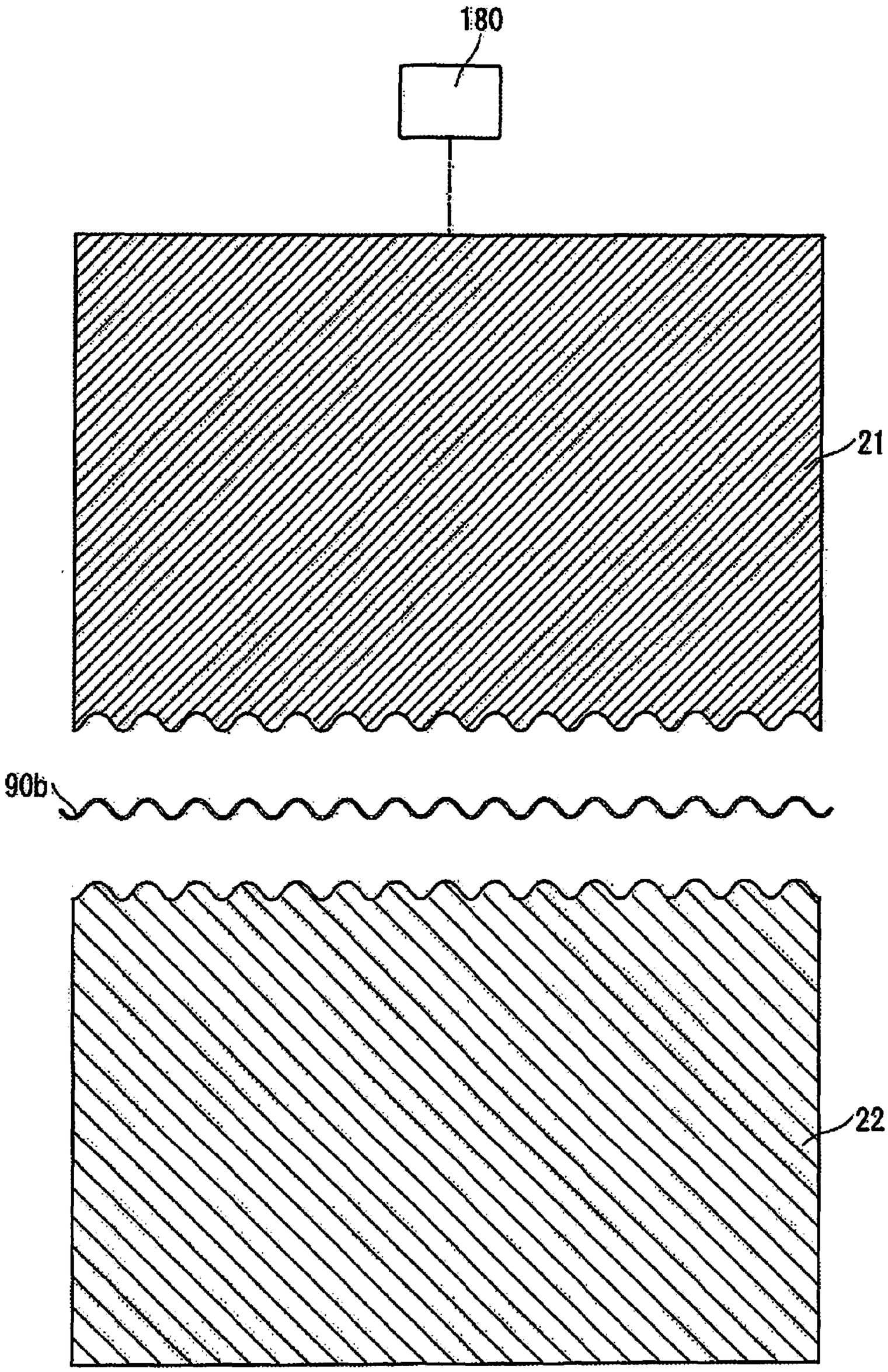


FIG. 8

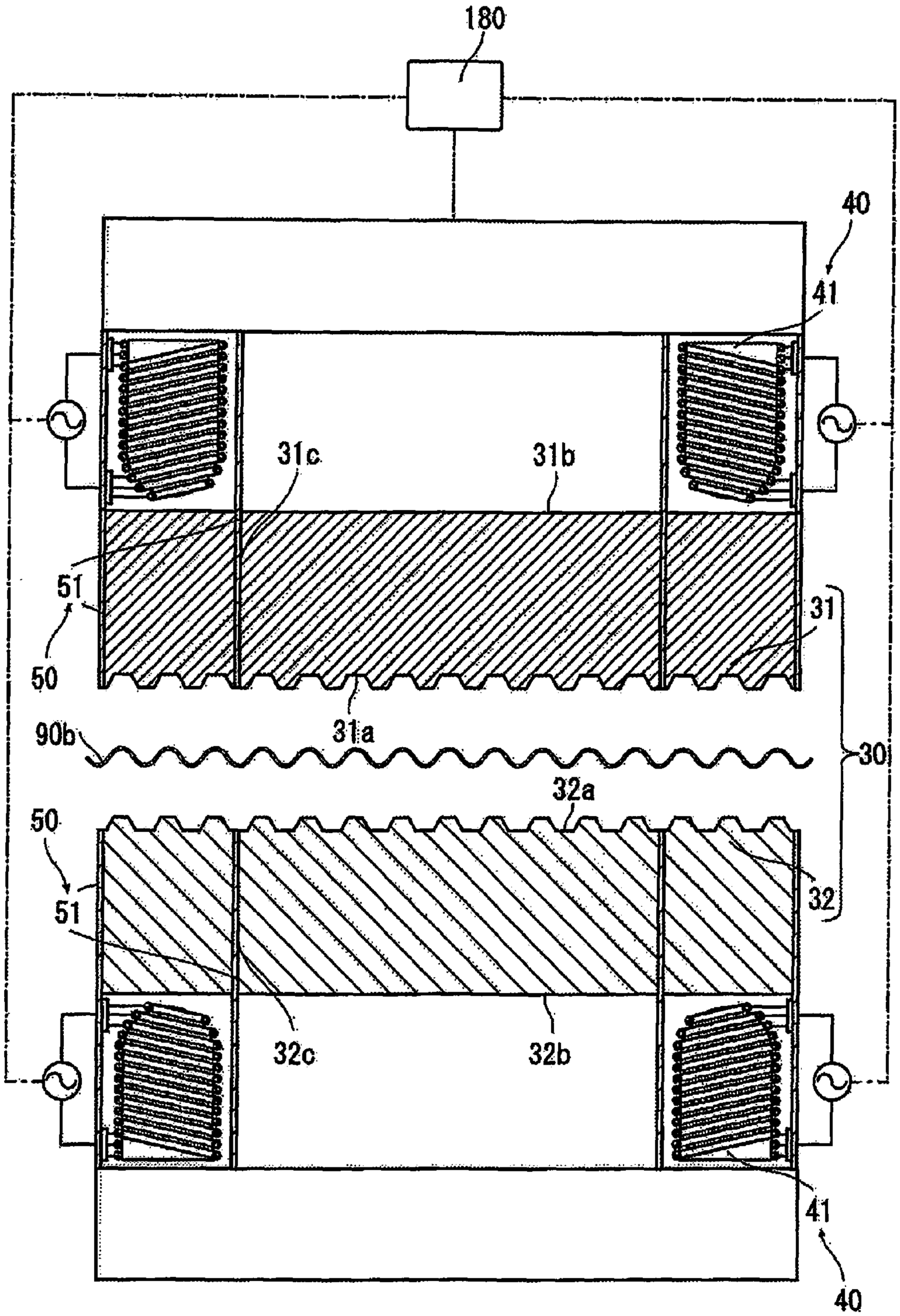


FIG. 9

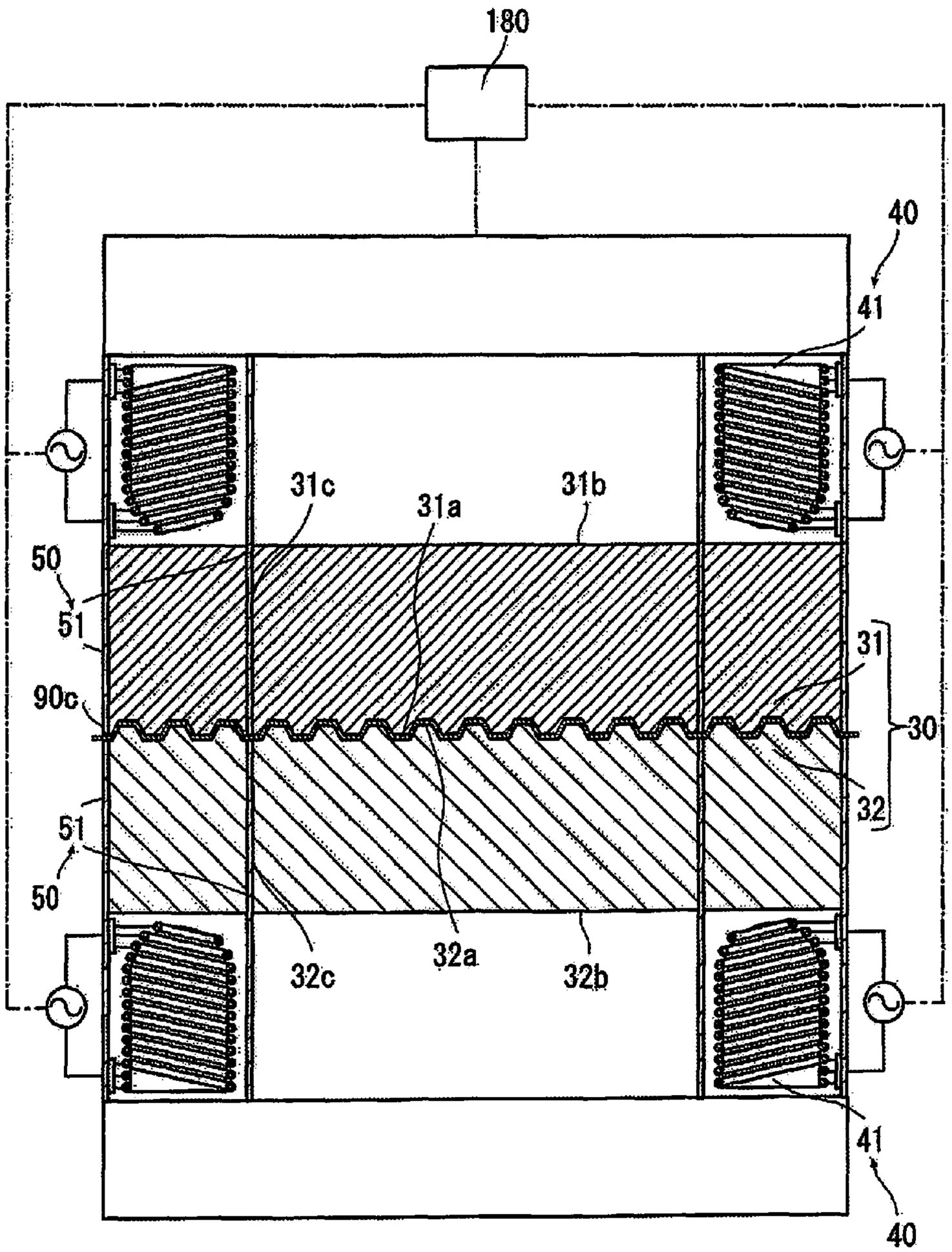


FIG. 10

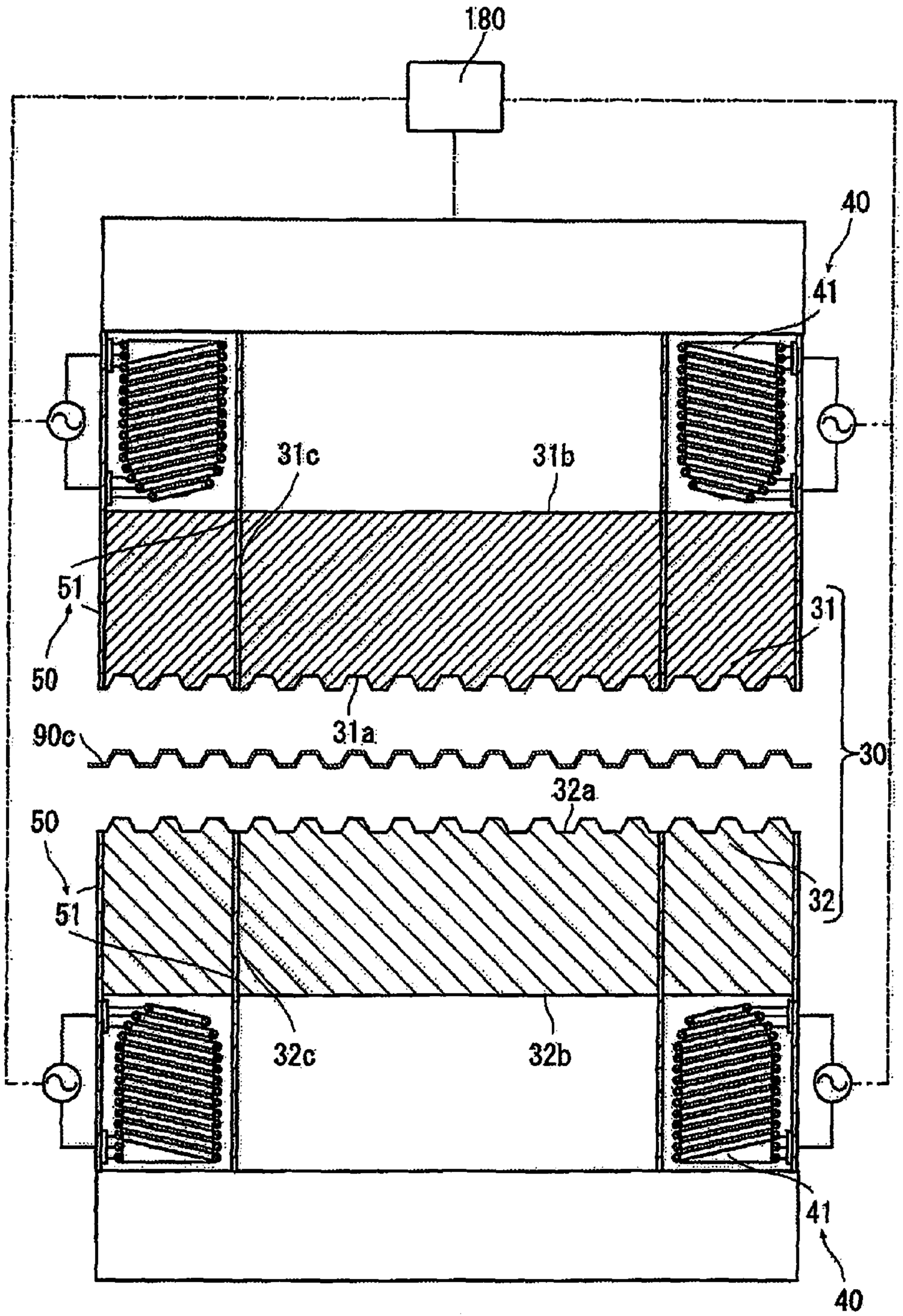


FIG. 11

METAL SEPARATOR MOLDING DEVICE AND METHOD FOR MOLDING METAL SEPARATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National stage application of International Application No. PCT/JP2014/059898, filed Apr. 3, 2014, which claims priority to Japanese Patent Application No. 2013-108064 filed in Japan on May 22, 2013.

BACKGROUND

Field of the Invention

The present invention relates to a device and method for molding a metal separator.

Background Information

A metal separator for a fuel battery is press molded using a press machine and a die (for example, see Japanese Laid-Open Patent Application No. 2008-84843 Channels through which a fuel gas, an oxidation gas, and cooling water (a coolant) all flow are formed by overlaying two metal separators.

SUMMARY

A metal separator for a fuel battery is commonly susceptible to wrinkling or other distortion because the separator is comparatively thin and is formed by press-molding a long strip of base material. Sufficient positional accuracy cannot be achieved with metal separators that have residual distortion, and such separators are difficult to position when layered over a membrane electrode assembly. Furthermore, because distortions remain in the thickness direction of the base material of the metal separator, the distortions lead to deformation of a cell module after the metal separator and the membrane electrode assembly are stacked to assemble the cell module. Therefore, how to remove distortions is an important problem in the molding of metal separators.

The present invention was devised in order to resolve the above-described problems encountered with conventional technology, it being an object of the invention to provide a device and method for molding a metal separator whereby distortions created during press molding are removed and the metal separator can be molded without any residual distortion.

The device for molding a metal separator according to the present invention, which achieves the purpose described above, press-molds a thin plate-shaped base material using a first die and a second die capable of moving towards and away from each other, and has a heating part, a processing part, and a controller. The heating part heats the thin plate-shaped base material. The processing part causes the thin plate-shaped base material heated by the heating part to be pressed by the first die and the second die to form channels through which a medium flows. The controller controls the operations of the heating part and the processing part.

The method for molding a metal separator according to the present invention, which achieves the purpose described above, press-molds a thin plate-shaped base material using a first die and a second die provided so as to be capable of moving towards and away from each other, and has a heating step and a processing step. In the heating step, the thin plate-shaped base material is heated. In the processing step, the heated thin plate-shaped base material is pressed using the first die and the second die to form channels through which a medium flows.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original disclosure.

FIG. **1** is a schematic diagram showing a device for molding a metal separator according to an embodiment of the present invention.

FIG. **2** is a schematic diagram showing a thin plate-shaped base material subjected to various molding processes using the molding device according to the embodiment.

FIG. **3** is a perspective view showing a metal separator molded by the molding device according to the embodiment.

FIG. **4** is an end surface view showing the configuration of a preparatory processing part of the molding device according to the embodiment.

FIG. **5** is an end surface view showing the configuration of a channel processing part, a second heating part, and an insulating part of the molding device according to the embodiment.

FIG. **6** is a flowchart showing the method of molding the metal separator according to the embodiment.

FIG. **7** is a flowchart showing the operations of the molding device according to the embodiment.

FIG. **8** is an end surface view showing the state in which the thin plate-shaped base material is conveyed out from the preparatory processing part of the molding device according to the embodiment after the preparatory molded article has finished being molded.

FIG. **9** is an end surface view showing the state in which the thin plate-shaped base material is conveyed in to the channel processing part of the molding device according to the embodiment after preparatory molding.

FIG. **10** is an end surface view showing the state in which the channels are formed in the thin plate-shaped base material by the channel processing part, the second heating part, and the insulating parts of the molding device according to the embodiment.

FIG. **11** is an end surface view showing the state in which the thin plate-shaped base material is conveyed out from the channel processing part of the molding device according to the embodiment after the channels are finished being molded.

DETAILED DESCRIPTION OF THE EMBODIMENTS

An embodiment according to the present invention is described below with reference to the accompanying drawings. There are cases in which the sizes and ratios of the components in the drawings are exaggerated for convenience in the description and are different from the actual sizes and ratios.

A device **100** for molding a metal separator **91** according to the present embodiment is described with reference to FIGS. **1** to **11**.

First, the configuration of the device **100** for molding the metal separator **91** is described with reference to FIGS. **1** to **5**.

FIG. **1** is a schematic diagram showing the device **100** for molding the metal separator **91**. FIG. **2** is a schematic diagram showing a thin plate-shaped base material **90** subjected to various molding processes using the molding device **100**. FIG. **3** is a perspective view showing a metal

separator **91** molded by the molding device **100**. FIG. **4** is an end surface view showing the configuration of a preparatory processing part **20** of the molding device **100**. FIG. **5** is an end surface view showing the configuration of a channel processing part **30**, a second heating part **40**, and insulating parts **50** of the molding device **100**.

The molding device **100** forms openings, irregularities, and the like in the area of a long strip of the thin plate-shaped base material **90** that will become the metal separator **91** shown in FIG. **3**. The openings are equivalent to, e.g., locating holes **90***a* and manifold holes **90***d* to **90***i* described hereinafter. The irregularities are equivalent to channels **90***c* and irregularities of a preparatory molded article **90***b*, described hereinafter. The molding device **100** includes an upper die **110**, a lower die **120**, an incoming feeder **130**, an outgoing conveyor **140**, an outgoing feeder **150**, and a controller **180**.

The upper die **110** and the lower die **120** have multiple types of press dies for molding the openings, irregularities, and the like in the thin plate-shaped base material **90**. The multiple types of press dies are arranged along the conveying direction of the thin plate-shaped base material **90**. The locating holes **90***a* for positioning, the irregular-shaped preparatory molded article **90***b*, the channels **90***c* for channeling a medium, and the manifold holes **90***d* to **90***i* for supplying and discharging the medium are molded into the thin plate-shaped base material **90** by the multiple types of press dies, as shown in FIG. **2**. The outer edge portion of the metal separator **91** is then punched to open up punch holes **90***j*. The manifold holes **90***d* to **90***i* are an anode gas supply port **90***d*, a cooling fluid supply port **90***e*, a cathode gas supply port **90***f*, a cathode gas discharge port **90***g*, a cooling fluid discharge port **90***h*, and an anode gas discharge port **90***i*, as shown in FIG. **3**. The anode gas is a fuel gas (hydrogen), and the cathode gas is an oxidation gas (air).

The incoming feeder **130** conveys the pre-processed thin plate-shaped base material **90** in between the upper die **110** and the lower die **120**. The incoming feeder **130** is provided on the upstream side of the upper die **110** and the lower die **120**. The outgoing conveyor **140** conveys the punched out metal separator **91** out from the thin plate-shaped base material **90**. The outgoing feeder **150** conveys the discarded thin plate-shaped base material **90** out from between the upper die **110** and the lower die **120** after the metal separator **91** has been punched out. The outgoing feeder **150** is provided on the downstream side of the upper die **110** and the lower die **120**. The controller **180** controls the speed and timing at which the thin plate-shaped base material **90** is conveyed in by the incoming feeder **130**, as well as the speed and timing at which the thin plate-shaped base material **90** is conveyed out by the outgoing feeder **150**. The controller **180** controls the movable upper die **110** so that after the upper die **110** is urged against the stationary lower die **120**, the upper die **110** is separated from the lower die **120**.

Next, the characteristic configuration of the device **100** for molding the metal separator **91** is described with reference to FIGS. **1**, **2**, **4**, and **5**.

The molding device **100** performs heating and processing on the thin plate-shaped base material **90**, and forms the channels **90***c* on the thin plate-shaped base material **90**. The molding device **100** press-molds the thin plate-shaped base material **90** using a channel-processing upper die **31** (equivalent to the first die) and a channel-processing lower die **32** (equivalent to the second die) which are capable of moving toward and away from each other. The molding device **100** has a first heating part **10** (equivalent to the heating part) and a channel-processing part **30** (equivalent to the processing part). The first heating part **10** heats the thin plate-shaped base material **90**. The channel-processing part **30** presses the heated thin plate-shaped base material **90** using the channel-processing upper die **31** and the channel-processing lower die **32** to form the channels **90***c* for channeling the medium. The controller **180** controls the operations of the first heating part **10** and the channel-processing part **30**.

The first heating part **10** is provided in order to sufficiently heat the thin plate-shaped base material **90** before the thin plate-shaped base material **90** is press-molded by the channel-processing part **30** to form the channels **90***c*. The first heating part **10** has first heating members **11** for heating the thin plate-shaped base material **90**, as shown in FIGS. **1** and **2**. The first heating members **11** are configured from something capable of heating the thin plate-shaped base material **90** instantly and uniformly, such as, e.g., high-frequency coils, far-infrared heaters, steam heaters, hot air blowers, or the like.

The first heating members **11** are provided both between the upper die **110** and the thin plate-shaped base material **90**, and between the lower die **120** and the thin plate-shaped base material **90**, in order to heat the upper and lower surfaces of the thin plate-shaped base material **90** as shown in FIG. **1**. A control performed by the controller **180** causes the first heating part **10** to begin to heat the thin plate-shaped base material **90** as the thin plate-shaped base material **90** begins to be conveyed by the molding device **100**. The first heating part **10** heats the area (first area a**1**) where the channels **90***c* are formed in the thin plate-shaped base material **90** conveyed by the molding device **100**. The heating by the first heating part **10** sufficiently softens the first area a**1** of the thin plate-shaped base material **90**.

The molding device **100** also has a preparatory processing part **20** for pre-molding the first area a**1** of the thin plate-shaped base material **90** to form the preparatory molded article **90***b*, before the heat-softened thin plate-shaped base material **90** is press-molded by the channel-processing part **30** to form the channels **90***c*. The preparatory molding by the preparatory processing part **20** is performed after the heat treatment by the first heating part **10**.

Before the channels **90***c* are molded into the thin plate-shaped base material **90**, the preparatory processing part **20** performs preparatory molding, which gives a preparatory shape to the thin plate-shaped base material **90**, to form the preparatory molded article **90***b* and then mold the channels **90***c*. The preparatory processing part **20** has a preparatory processing upper die **21** that operates in coordination with the upper die **110**, and a preparatory processing lower die **22** fixed in place in the same manner as the lower die **120**, as shown in FIG. **4**. Using the preparatory processing upper die **21** and the preparatory processing lower die **22**, the preparatory processing part **20** presses the thin plate-shaped base material **90**, softened by the heating of the first heating part **10**, to form the preparatory molded article **90***b*. The aforementioned preparatory shape of the thin plate-shaped base material **90** is, e.g., a concave open shape where the channels **90***c* are easily processed by the channel-processing part **30**. After the softened thin plate-shaped base material **90** is pressed in the preparatory processing part **20** to form the preparatory molded article **90***b*, the preparatory molded article **90***b* is pressed in the channel-processing part **30** to form the channels **90***c*. Thus, because the thin plate-shaped base material **90** is incrementally bent by forming the preparatory molded article **90***b* in the preparatory processing part **20**, channels **90***c* free of wrinkles and other distortions can be formed.

The channel-processing part **30** is provided in order to press the softened preparatory molded article **90***b* formed by the preparatory processing part **20** to mold the channels **90***c*. The channel-processing part **30** has the channel-processing upper die **31**, which operates in coordination with the upper die **110**, and the channel-processing lower die **32**, which is fixed in place similar to the lower die **120**, as shown in FIG. **5**. When the preparatory molded article **90***b* softened by the channel-processing upper die **31** and the channel-processing lower die **32** is pressed to begin forming the channels **90***c*, there are virtually no wrinkles or other distortions in the channels **90***c* formed. Because the preparatory molded article **90***b* is pressed while the channel-processing part **30** is soft, wrinkles and other distortions are pushed out to the outer periphery of the first area a**1** where the channels **90***c* formed by pressing the channel-processing part **30** are formed, and wrinkles and other distortions are not likely to remain in the middle of the first area a**1**.

In the molding device **100**, the thin plate-shaped base material **90** is heated by the first heating part **10** as described above, and in the channel-processing part **30**, the heated thin plate-shaped base material **90** is pressed by the channel-processing upper die **31** and the channel-processing lower die **32**. Because the thin plate-shaped base material **90** is thus pressed by the channel-processing upper die **31** and the channel-processing lower die **32** after having been heated and softened, wrinkles and other distortions created during press molding can be removed in the surface direction and the metal separator **91** can be molded without any residual distortions.

Due to having the configuration described above, the molding device **100** can mold the metal separator **91** without any residual wrinkles or other distortions created during press molding, but the molding device **100** also has the configuration described below in order to more reliably remove distortions. The further configuration of the molding device **100** is described below with reference to FIG. **5**.

The molding device **100** also has a second heating part **40** (equivalent to the other heating part) for heating parts of the outer periphery of the area (the first area a**1**) of the thin plate-shaped base material **90** where the channels **90***c* are formed, when the channels **90***c* are formed by the channel-processing upper die **31** and the channel-processing lower die **32**.

The second heating part **40** is provided in order to remove wrinkles and other distortions pushed out to the outer periphery of the first area a**1** in the thin plate-shaped base material **90** where the channels **90***c* are formed, when the channel-processing part **30** has pushed the softened thin plate-shaped base material **90** to form the channels **90***c*. The second heating part **40** has a plurality of second heating members **41** for heating the channel-processing upper die **31** on the side of an upper surface **31***b*, which is the side of the channel-processing upper die **31** opposite a pressing surface **31***a* that presses the thin plate-shaped base material **90**. The second heating part **40** also has a plurality of second heating members **41** for heating the channel-processing lower die **32** on the side of a lower surface **32***b*, which is the side of the channel-processing lower die **32** opposite a pressing surface **32***a* that presses the thin plate-shaped base material **90**. The second heating members **41** are provided to parts of the outer peripheries of the upper surface **31***b* of the channel-processing upper die **31** and the lower surface **32***b* of the channel-processing lower die **32**. The second heating members **41** are directly attached to the channel-processing upper die **31** and the channel-processing lower die **32**. The second heating members **41** are configured from something capable of heating parts of the outer periphery of the thin plate-shaped base material **90** instantly and uniformly, such as, e.g., high-frequency coils, far-infrared heaters, steam heaters, hot air blowers, or the like.

When a predetermined time duration has elapsed after the thin plate-shaped base material **90** is pressed by the channel-processing upper die **31** and the channel-processing lower die **32** to begin molding the channels **90***c*, the second heating members **41** are controlled by the controller **180** to begin heating. The second heating members **41** heat parts of the outer periphery (the second areas a**2**) of the first area a**1** of the thin plate-shaped base material **90** pressed by the channel-processing part **30** to form the channels **90***c*. Wrinkles and other distortions pushed out to the outer periphery of the first area a**1** of the thin plate-shaped base material **90** by the pressure are pushed farther out to the ends of the outer periphery of the second areas a**2**, because the second areas a**2** are particularly softened by the second heating part **40** heating the second areas a**2** of the thin plate-shaped base material **90**. Thus, while the thin plate-shaped base material **90** is being pressed by the channel-processing part **30** to form the channels **90***c*, the second areas a**2**, which are parts of the outer periphery of the first area a**1** of the thin plate-shaped base material **90**, are heated by the second heating part **40**, whereby wrinkles and other distortions in the channels **90***c* can be reliably removed. Through the control of the controller **180**, the supply of electric power to the second heating members **41** is cut off at the same time that the molding of the channels **90***c* is complete and the channel-processing upper die **31** separates from the channel-processing lower die **32**, and heating is stopped.

The second heating part **40** heats the four corners of the rectangular-shaped area.

In the outer periphery of the first area a**1** where the channel-processing part **30** presses the thin plate-shaped base material **90** to form the channels **90***c*, wrinkles and other distortions are likely to remain towards the four corners farthest from the middle of the first area a**1**. Therefore the second heating part **40** is provided in order to remove wrinkles and other distortions pushed out towards the four corners in the outer periphery of the first area a**1** of the thin plate-shaped base material **90** where the channels **90***c* are formed. The second heating members **41** are provided to the four corners of both the upper surface **31***b* of the channel-processing upper die **31** and the lower surface **32***b* of the channel-processing lower die **32**, as shown in FIG. **5**. Wrinkles and other distortions pushed out towards the four corners of the channels **90***c* by the pressure of the channel-processing part **30** are pushed further out towards the ends of the second areas a**2**, because the second areas a**2** are particularly softened by the second heating part **40** heating the four corners (the second areas a**2**) of the channels **90***c*. Thus, while the thin plate-shaped base material **90** is pressed by the channel-processing part **30** to form the channels **90***c*, the second areas a**2**, which are the four corners of the first area a**1** of the thin plate-shaped base material **90**, are heated by the second heating part **40**, whereby wrinkles and other distortions in the channels **90***c* can be more reliably removed.

The molding device **100** also has insulating parts **50** which are provided to the channel-processing part **30**, and which insulate and separate the second areas (equivalent to areas of part of the outer periphery) a**2** and other areas in the first area a**1** of the thin plate-shaped base material **90** where the channels **90***c* are formed.

The insulating parts **50** are provided so that the second heating part **40** heats only part of the outer periphery of the

first area a**1** where the channels **90***c* are formed. The insulating parts **50** are provided to both the channel-processing upper die **31** and the channel-processing lower die **32**, as shown in FIG. **5**. When the channel-processing upper die **31** and the channel-processing lower die **32** form the channels **90***c* in the thin plate-shaped base material **90**, the insulating parts **50** separate the second areas a**2** and the other areas in the first area a**1** of the thin plate-shaped base material **90**, and prevent heat from being transferred between these areas. The insulating parts **50** have insulating members **51** in part of the outer periphery of the four corners of the channel-processing upper die **31** and the channel-processing lower die **32**.

The insulating members **51** are configured from heat-insulating, very hard members, e.g. from a ceramic (including glass). The insulating members **51** are shaped to enclose the second heating members **41** as shown in FIG. **5** and other drawings, and are configured from cylindrical shapes when the second heating members **41** are, e.g., coil-shaped heating members. The insulating members **51** are installed in grooves **31***c* processed into the channel-processing upper die **31** and grooves **32***c* processed into the channel-processing lower die **32**, as shown in FIG. **4**.

First, the first heating part **10** heats the first area a**1** of the range in the thin plate-shaped base material **90** where the channels **90***c* are formed (the first heating), as shown in FIG. **2**. The softened thin plate-shaped base material **90** is then press-molded in the preparatory processing part **20** and the channel processing part **30** to form the channels **90***c*. When the channel processing part **30** presses the thin plate-shaped base material **90** to form the channels **90***c*, the second areas a**2**, which are parts of the outer periphery or the four corners of the first area a**1**, are heated by the second heating part **40** (the second heating). Providing the insulating parts **50** makes it possible to ensure that the respective second heating members **41** of the second heating part **40** heat only the second areas a**2** of the thin plate-shaped base material **90**. Therefore, heat transfer between the second areas a**2** and other areas in the first area a**1** of the thin plate-shaped base material **90** can be blocked by providing the insulating parts **50**. Two-stage heating with a time lag can thereby be performed on the thin plate-shaped base material **90** by the first heating part **10** and the second heating part **40**.

When the controller **180** forms the channels **90***c* using the channel-processing upper die **31** and the channel-processing lower die **32**, the controller heats parts of the outer periphery of the channels **90***c* using the second heating part **40**.

The controller **180** controls the heating operations of the first heating part **10** and the second heating part **40**. The controller **180** includes a ROM, CPU, and RAM. The ROM (read only memory) stores control programs for controlling the heating operations of the first heating part **10** and the second heating part **40**.

The channel-processing upper die **31** and the channel-processing lower die **32** preferably have mutually different die temperatures when the channels **90***c* are being formed.

In order to control the die temperatures of both the channel-processing upper die **31** and the channel-processing lower die **32**, the controller **180** controls the heating temperatures of the second heating members **41** installed on the channel-processing upper die **31** side and the second heating members **41** installed on the channel-processing lower die **32** side. The controller **180** controls the die temperatures so that the die temperature of the channel-processing lower die **32** is lower than the die temperature of the channel-processing upper die **31**. Due to this heating control, when the channel-processing upper die **31** and the channel-processing lower die **32** are separated, the thin plate-shaped base material **90** in which the channels **90***c* are formed sticks to the channel-processing lower die **32** side due to shrinkage deformation. Because the thin plate-shaped base material **90** in which the channels **90***c* are formed sticks to the channel-processing lower die **32** side, the base material can be easily conveyed without creating wrinkles or other distortions to the next processing part that forms the manifold holes **90***d* to **90***i* as shown in FIG. **2**.

Next, the method of molding the metal separator **91** (see FIG. **2**) is described with reference to FIG. **6**.

FIG. **6** is a flowchart showing the method of molding the metal separator **91**.

In the method of molding the metal separator **91**, the thin plate-shaped base material **90** (see FIG. **2**) is press-molded by the channel-processing upper die **31** (equivalent to the first die, see FIG. **5**) and the channel-processing lower die **32** (equivalent to the second die, see FIG. **5**), which are provided so as to be capable of moving toward and away from each other. The molding method has a heating step and a processing step, as shown in FIG. **6**. In the heating step, the thin plate-shaped base material **90** is heated. In the processing step, the heated thin plate-shaped base material **90** is pressed by the channel-processing upper die **31** and the channel-processing lower die **32** to form the channels **90***c* (see FIG. **2**) through which a medium is channeled. The molding device **100** described above is a molding device that embodies the method of molding the metal separator **91**.

Next, the operations of the molding device **100** will be described with reference to FIGS. **8** to **11** in addition to the flowchart of FIG. **7**.

FIG. **7** is a flowchart showing the operations of the molding device **100**. FIG. **8** is an end surface view showing the state in which the thin plate-shaped base material **90** is conveyed out from the preparatory processing part **20** of the molding device **100** after the preparatory molded article **90***b* has finished being molded. FIG. **9** is an end surface view showing the state in which the thin plate-shaped base material **90** is conveyed in to the channel processing part **30** of the molding device **100** after preparatory molding. FIG. **10** is an end surface view showing the state in which the channels **90***c* are formed in the thin plate-shaped base material **90** by the channel processing part **30**, the second heating part **40**, and the insulating parts **50** of the molding device **100**. FIG. **11** is an end surface view showing the state in which the thin plate-shaped base material **90** is conveyed out from the channel processing part **30** of the molding device **100** after the channels **90***c* are finished being molded.

When the molding device **100** begins molding ("START"), the first heating members **11** of the first heating part **10** are controlled by the controller **180** to begin heating, as shown in FIGS. **1** and **2**. The first heating part **10** heats the area (the first area a**1**) where the channels **90***c* are formed in the thin plate-shaped base material **90** conveyed by the molding device **100** (step S**1**). The first area a**1** of the thin plate-shaped base material **90** is sufficiently softened by being heated by the first heating part **10**. When the molding device **100** conveys the thin plate-shaped base material **90** by a predetermined pitch, the portioned softened by being heated by the first heating part **10** reaches the preparatory processing part **20**.

The preparatory processing part **20** presses the thin plate-shaped base material **90** using the preparatory processing upper die **21** and the preparatory processing lower die **22**, forming the preparatory molded article **90***b* (step S**2**). When the molding device **100** conveys the thin plate-shaped base material **90** by a predetermined pitch, the portion of the

preparatory molded article **90***b* formed by the preparatory molding of the preparatory processing part **20** reaches the channel processing part **30**.

While the channel-processing upper die **31** is separated from the channel-processing lower die **32** as shown in FIG. **9**, the channel processing part **30** conveys the thin plate-shaped base material in between the two dies (step S**3**).

The channel processing part **30** places the thin plate-shaped base material **90** on the channel-processing lower die **32** so that the irregular shape of the conveyed in preparatory molded article **90***b* corresponds to the irregular shape of the channel-processing lower die **32**. Next, the channel processing part **30** is controlled by the controller **180** to lower the channel-processing upper die **31** toward the channel-processing lower die **32** and the thin plate-shaped base material **90** in which the preparatory molded article **90***b* is formed. The channel-processing upper die **31** pushes out the preparatory molded article **90***b* formed in the thin plate-shaped base material **90** to face downward in the drawing.

When the channel-processing upper die **31** is finished lowering, the pressing surface **31***a* of the channel-processing upper die **31** and the pressing surface **32***a* of the channel-processing lower die **32** begin pressing the preparatory molded article **90***b* formed in the thin plate-shaped base material **90**, as shown in FIG. **10**. Because the preparatory molded article **90***b* formed in the thin plate-shaped base material **90** is softened, when the preparatory molded article **90***b* is pressed to form the channels **90***c*, wrinkles and other distortions are gradually pushed out particularly to the four corners of the outer periphery of the first area a**1** where the channels **90***c* are formed.

Next, when a predetermined time elapses after the channel-processing upper die **31** and the channel-processing lower die **32** press the thin plate-shaped base material **90** to begin forming the channels **90***c*, the second heating part **40** is controlled by the controller **180** to supply electric power to the respective second heating members **41**. The respective second heating members **41** begin heating due to the supply of electric power, and the four corners of the channel-processing upper die **31** and the channel-processing lower die **32** begin to be heated. At this time, the controller **180** controls the die temperatures so that the die temperature of the channel-processing lower die **32** is lower than the die temperature of the channel-processing upper die **31**.

When the respective four corners of the channel-processing upper die **31** and the channel-processing lower die **32** begin to be heated, the four corners (the second areas) of the first area a**1** of the thin plate-shaped base material **90** pressed while heated by these dies are further softened. Wrinkles and other distortions pushed out to the four corners (the second areas) of the first area a**1** of the thin plate-shaped base material **90** are thereby further pushed out towards the ends of the second areas a**2** (step S**4**).

Next, the channel-processing upper die **31** is controlled by the controller **180** to move away from the channel-processing lower die **32**. The separating of the channel-processing upper die **31** from the channel-processing lower die **32** completes the molding of the channels **90***c* from which wrinkles and other distortions have been removed (step S**5**). The supply of electric power to the second heating members **41** is cut off by the control of the controller **180** at the same time that the channel-processing upper die **31** separates from the channel-processing lower die **32**, and heating is stopped. When the molding device **100** conveys the thin plate-shaped base material **90** by a predetermined pitch, the thin plate-shaped base material **90** in which the channels **90***c* have finished being molded is conveyed to a press die for taking the base material off. Hereinafter in the molding device **100**, the metal separator **91** is punched out of the thin plate-shaped base material **90** after the manifold holes **90***d* to **90***i* have been formed. The outgoing conveyor **140** conveys out the punched out metal separator **91**, and the outgoing feeder **150** conveys out the thin plate-shaped base material **90** which is to be destroyed after the metal separator **91** has been punched out.

The following operative effects are exhibits by the molding device **100** for a metal separator according to the embodiment described above.

In the present device **100** for molding the metal separator **91**, the thin plate-shaped base material **90** is press-molded by the channel-processing upper die **31** (the first die) and the channel-processing lower die **32** (the second die) which are provided to be capable of moving towards and away from each other. The device **100** for molding the metal separator **91** has a first heating part **10** (the heating part), a channel processing part **30** (the processing part), and a controller **180**. The first heating part **10** heats the thin plate-shaped base material **90**. The channel processing part **30** presses the heated thin plate-shaped base material **90** using the channel-processing upper die **31** and the channel-processing lower die **32** to form channels **90***c* through which a medium flows. The controller **180** controls the operations of the first heating part **10** and the channel processing part **30**.

With this configuration, the thin plate-shaped base material **90** is heated by the first heating part **10**, and the heated thin plate-shaped base material **90** is pressed by the channel-processing upper die **31** and the channel-processing lower die **32** in the channel processing part **30**. Because the thin plate-shaped base material **90** is thus pressed by the channel-processing upper die **31** and the channel-processing lower die **32** after having been heated and softened, wrinkles and other distortions created during press molding can be removed in the surface direction and the metal separator can be molded without any residual distortions. As a result of no distortions remaining in the metal separator, sufficient positional accuracy can be obtained, and the metal separator is easily positioned when layered over a membrane electrode assembly. Furthermore, because no distortions remain in the metal separator in the thickness direction of the base material, after the metal separator and a membrane electrode assembly are stacked to assemble a cell module, deformation of the cell module can also be prevented.

There is also a second heating part **40** (the other heating part), provided to the channel processing part **30**, for heating parts of the outer periphery (the second areas a**2**) of the area (the first area a**1**) in the thin plate-shaped base material **90** where the channels **90***c* are formed, and the controller **180** preferably heats parts of the outer periphery of the channels **90***c* by means of the second heating part **40** when the channels **90***c* are formed by the channel-processing upper die **31** (the first die) and the channel-processing lower die **32** (the second die).

With this configuration, because parts of the outer periphery (the second areas a**2**) of the first area a**1** of the thin plate-shaped base material **90** are heated by the second heating part **40**, wrinkles and other distortions can be further pushed out towards the ends of the second areas a**2**. Thus, the thin plate-shaped base material **90** is heated in two stages by the first heating part **10** and the second heating part **40**, whereby wrinkles and other distortions created during press molding can be reliably removed in the surface direction.

The second heating part **40** (the other heating part) preferably heats the four corners (the second areas) of the rectangular-shaped first area a**1** (the area).

With this configuration, because the four corners (the second areas a**2**) in the outer periphery of the first area a**1** of the thin plate-shaped base material **90** are heated by the second heating part **40**, wrinkles and other distortions can be further pushed out towards the ends of the second areas a**2**. Thus, the thin plate-shaped base material **90** is heated in two stages by the first heating part **10** and the second heating part **40**, whereby wrinkles and other distortions created during press molding can be reliably removed in the surface direction.

The area (the first area a**1**) of the thin plate-shaped base material **90** where the channels **90***c* are formed, also preferably has the insulating parts **50**, which are provided to the channel processing part **30** (the processing part) and which insulate and separate the areas of parts of the outer periphery (the second areas a**2**) and the other areas.

With this configuration, heat transfer between the second areas a**2** (parts or the four corners of the outer periphery of the channels **90***c*) of the thin plate-shaped base material **90** and the other areas can be blocked by providing the insulating parts **50**. Two-stage heating with a time difference can thereby be performed by the first heating part **10** for heating the first area a**1** and the second heating part **40** for heating the second areas a**2**.

The channel-processing upper die **31** (the first die) and the channel-processing lower die **32** (the second die) preferably have different respective die temperatures when the channels **90***c* are being formed.

With this configuration, the die temperatures are preferably controlled by the controller **180** so that the die temperature of the channel-processing lower die **32** is lower than the die temperature of the channel-processing upper die **31**. This heating control causes the thin plate-shaped base material **90** in which the channels **90***c* are formed to stick to the channel-processing lower die **32** side due to shrinkage deformation when the channel-processing upper die **31** and the channel-processing lower die **32** are separated. Because the thin plate-shaped base material **90** in which the channels **90***c* are formed thus sticks to the channel-processing lower die **32** side, the base material can easily be conveyed without creating wrinkles and other distortions to the next processing part for forming the manifold holes **90***d* to **90***i* as shown in FIG. **2**.

The following operative effects are exhibited by the method for molding a metal separator according to the embodiment described above.

In the present method for molding the metal separator **91**, the thin plate-shaped base material **90** is press-molded by the channel-processing upper die **31** (the first die) and the channel-processing lower die **32** (the second die) which are provided to be capable of moving towards and away from each other, and the method has a heating step and a processing step. The heating step heats the thin plate-shaped base material **90**. The processing step presses the heated thin plate-shaped base material **90** by means of the channel-processing upper die **31** and the channel-processing lower die **32** to form the channels **90***c* through which a medium flows.

With this method, the heated thin plate-shaped base material **90** is pressed by the channel-processing upper die **31** (the first die) and the channel-processing lower die **32** (the second die). Because the thin plate-shaped base material **90** is thus pressed by the channel-processing upper die **31** and the channel-processing lower die **32** after having been heated and softened, wrinkles and other distortions created during press molding can be removed in the surface direction and the metal separator can be molded without any residual distortions. As a result of there being no distortions remaining in the metal separator, sufficient positional accuracy can be obtained, and the metal separator is easily positioned when layered over a membrane electrode assembly. Furthermore, because no distortions remain in the metal separator in the thickness direction of the base material, after the metal separator and a membrane electrode assembly are stacked to assemble a cell module, deformation of the cell module can also be prevented.

In the processing step, parts of the outer periphery (the second areas a**2**) of the area (the first area a**1**) of the thin plate-shaped base material **90** where the channels **90***c* are formed are preferably heated.

With this method, because parts of the outer periphery (the second areas a**2**) of the first area a**1** of the thin plate-shaped base material **90** are heated, wrinkles and other distortions can be further pushed out towards the ends of the second areas a**2**. Thus, the thin plate-shaped base material **90** is heated in two stages, whereby wrinkles and other distortions created during press molding can be reliably removed in the surface direction.

In the processing step, the four corners (the second areas) of the rectangular-shaped first area a**1** (the area) are preferably heated.

With this method, because the four corners (the second areas a**2**) in the outer periphery of the first area a**1** of the thin plate-shaped base material **90** are heated in the processing step, wrinkles and other distortions can be further pushed out towards the ends of the second areas a**2**. Thus, the thin plate-shaped base material **90** is heated in two stages by the first heating part **10** and the second heating part **40**, whereby wrinkles and other distortions created during press molding can be reliably removed in the surface direction.

The channel-processing upper die **31** and the channel-processing lower die **32** preferably have different respective die temperatures when the channels **90***c* are being formed.

With this method, the die temperature of the channel-processing lower die **32** can be made lower than the die temperature of the channel-processing upper die **31**. Doing so causes the thin plate-shaped base material **90** in which the channels **90***c* are formed to stick to the channel-processing lower die **32** side due to shrinkage deformation when the channel-processing upper die **31** and the channel-processing lower die **32** are separated. Because the thin plate-shaped base material **90** in which the channels **90***c* are formed thus sticks to the channel-processing lower die **32** side, the base material can easily be conveyed without creating wrinkles and other distortions to the next processing part for forming the manifold holes **90***d* to **90***i* as shown in FIG. **2**.

Additionally, various modifications can be made to the present invention on the basis of the configuration set forth in the patent claims, and such modifications would belong to the category of the present invention.

For example, the present embodiment described a configuration in which the upper die **110** (including the preparatory processing upper die **21** and the channel-processing upper die **31**) was a movable die and the lower die **120** (including the preparatory processing lower die **22** and the channel-processing lower die **32**) was a stationary die. However, the invention is not limited to this configuration; e.g., the upper die **110** and the lower die **120** can be movable dies configured to be capable of moving towards and away from each other.

The present invention depicted an embodiment in which the die temperature of the channel-processing lower die **32** was made lower than the die temperature of the channel-processing upper die **31**, but the opposite is also possible, to

make the die temperature of the channel-processing lower die **32** higher than the die temperature of the channel-processing upper die **31**. In this case, the thin plate-shaped base material **90** in which the channels **90***c* are formed can be made to stick to the channel-processing upper die **31** side.

The invention claimed is:

1. A metal separator molding device for molding a metal separator by press-molding a thin plate-shaped base material using a first die and a second die capable of moving towards and away from each other, the metal separator molding device comprising:

a first heating part configured to heat the thin plate-shaped base material;

a processing part configured to press the thin plate-shaped base material heated by the first heating part using the first die and the second die to form channels through which a medium is configured to flow;

a second heating part configured to concentrate heat in four corners of an outer periphery of the thin plate-shaped base material where the channels are formed, the processing part including the second heating part, the outer periphery defining a rectangular shaped area; and

a controller configured to control operations of the first and second heating parts and the processing part, the controller being further configured to control the second heating part to heat the area of the outer periphery with the channels while the channels are being formed by the first die and the second die to substantially eliminate distortions in the surface direction formed during press-molding.

2. The metal separator molding device according to claim **1**, further comprising

a plurality of insulating parts arranged to insulate and divide the four corners of the outer periphery and a remaining area of the outer periphery of the thin plate-shaped base material where the channels are formed, the processing part including the insulating parts.

3. The metal separator molding device according to claim **1**, wherein

the thin plate-shaped base material is conveyed under tension.

4. The metal separator molding device according to claim **3**, wherein

the channels are formed in a direction orthogonal to a conveying direction.

5. A metal separator molding device for molding a metal separator by press-molding a thin plate-shaped base material using a first die and a second die capable of moving towards and away from each other, the metal separator molding device comprising:

a first heating part configured to heat the thin plate-shaped base material;

a preparatory processing part configured to form a preparatory molded article with a preparatory processing first die and a preparatory processing second die from the heated thin plate-shaped base material;

a processing part configured to press the preparatory molded article formed by the preparatory processing part using the first die and the second die to form channels through which a medium is configured to flow, the first and second dies being heated;

a second heating part configured to heat a portion of an outer periphery of the preparatory molded article when the preparatory molded article is being pressed by the first die and the second die of the processing part;

a thermal insulating part configured to insulate and separate the portion of the outer periphery from a remaining portion of the outer periphery of the preparatory molded article such that the second heating part only heats the portion of the outer periphery; and

a controller configured to control operations of the first heating part, the preparatory processing part, the processing part and the second heating part,

the first die and the second die having different die temperatures while the channels are being formed.

6. The metal separator molding device according to claim **5**, wherein

the thin plate-shaped base material is conveyed under tension.

7. The metal separator molding device according to claim **6**, wherein

the channels are formed in a direction orthogonal to a conveying direction.

8. A method for molding a metal separator in which a thin plate-shaped base material is press-molded by moving a first die and a second die towards and away from each other, the method comprising:

a heating step of heating the thin plate-shaped base material; and

a processing step of pressing the heated thin plate-shaped base material using the first die and the second die to form channels through which a medium is configured to flow;

in the processing step, heating is concentrated in four corners of an outer periphery of the thin plate-shaped base material where the channels are formed to substantially eliminate distortions in the surface direction formed during press-molding, the outer periphery defining a rectangular-shaped area.

9. The method according to claim **8**, further comprising conveying the thin plate-shaped base material under tension.

10. The method according to claim **9**, further comprising forming the channels in a direction orthogonal to a conveying direction.

11. A method for molding a metal separator in which a thin plate-shaped base material is press-molded by moving a first die and a second die towards and away from each other, the method for molding the metal separator comprising

a first heating step of heating the thin plate-shaped base material;

a preparatory processing step of forming a preparatory molded article with a preparatory processing first die and a preparatory processing second die from the heated thin plate-shaped base material;

a processing step of pressing the preparatory molded article using the first die and the second die to form channels through which a medium is configured to flow; and

a second heating step of heating the first die and the second die in an insulated state to concentrate heat in a portion of an outer periphery of the preparatory molded article when the preparatory molded article is being pressed by the first die and the second die of the processing part, the first die and the second die being provided with different die temperatures during press molding.

12. The method according to claim **11**, further comprising conveying the thin plate-shaped base material under tension.

13. The method according to claim 12, further comprising forming the channels in a direction orthogonal to a conveying direction.

* * * * *